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Health aspects involved in hay soaking – regarding the horse

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I List of abbreviations

AG FUKO = „Arbeitsgemeinschaft Futtersaaten, Futterbau und Futterkonservierung”
DE = Digestible Energy
DM= Dry Matter
LWK = Landwirtschaftskammer = chamber of agriculture
MJ =Mega Joule

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1. Abstract

It is commonly known that a high quality feed is essential for the health of the horse. Nevertheless the ingredients and the associated health problems are not entirely clear for the ordinary horse owner. Therefore the hay and haylage will be described, the production as well as the ingredients to gain a better understanding of the material. The fructan is a sugar within the plant. The horse cannot cope with a high intake of the fructan. The effect of a high intake is equine laminitis. That is why an examination of the fructan level in grass, hay and haylage was needed. The examination was performed by the chamber of agriculture. A study analysed the fructan level of grass hay and haylage. The data showed that a high fructan level occurs often in grass and hay and not so often in haylage. The fructan is water-soluble and therefore it is possible to wash it out of the hay. An experiment was performed to test if soaking the hay for a long time is more effective than for a short time. The hay samples for the experiment were taken to the laboratory of the chamber of agriculture called "Dasselsbruch" near Hannover, Germany. The analysis of the fructan level was performed with the NIRS method.

The outcome of the analysis was processed with SPSS. The result is that out of eight hay sample groups, six had the lowest fructan level after soaking the hay for 12 hours.

For horse owners with a horse suffering from laminitis it is important to reduce sugar as much as possible in the horses' diet. Therefore the supplements are cancelled as well as goodies or grazing. The next logical step is to reduce the sugar within the hay. The horse owner could either buy hay with a low fructan level or soak the own hay twelve hours to reduce the fructan level. For Horse owners who had the owned hay analysed and it has a risky fructan level it is easier to soak the hay than buying new hay. That is assuming that the horse owner wants to have healthy horses' and therefore reduce the risk of getting a horse with laminitis.

Foreword

The idea for the thesis developed out of a personal need. I have two sick horses one is suffering from laminitis and the other one from an allergy against dust. Different veterinarians believe that soaking hay will reduce the amount of fructan in the hay, which should be the cause for laminitis and by the way the dust within the hay is also reduced. The question which came to my mind was how long should the hay be soaked? Therefore I looked for a way to get the answers. I got in contact with the Dipl. Ing. Gerd Lange a member of the chamber of agriculture in Hannover. He believes in reducing the fructan level by soaking the hay. Together we developed the outline for the Thesis and the experiment.

2. Introduction

The horses' evolution started with the Eohippus who was a small, primitive horse about the size of a fox. The structure of the teeth suggests that it was a browser. Within the years the temperature and climate changed; the forest thinned and grass became more prevalent. Over millions of years the ancestors evolved as grazers, with specialized digestive tracts adapted to digest and utilize diets containing high levels of plant fibre. The horse was designed to spend eighteen hours a day grazing on a wide steppe. The domesticated horse has to deal with a different situation than its wild living relatives. The grass provided by the human is rich in content and differs from the poor steppe grass. (Parker 2003)

The horses' digestive tract has not adapted to all the new circumstances. That is why horses develop different diseases. The diseases called Equine Laminitis will be described within this study. One of the causes of Laminitis is a high fructan level in the grass or hay. That is why the study will have a close look at the fructan level within the hay as well.

A previous study done by the chamber of agriculture indicates that soaking hay reduces the fructan level. That is why this study will investigate if that is true and how long the hay must be soaked for the best outcome. The questions which will be answered are:

Main question: Does soaking hay reduce the fructan amount in the hay?

Sub questions: Which are the dangerous ingredients in the hay?

What are the consequences for the horse?

Where is the connection between fructan and laminitis?

How high is the dangerous fructan level?

Is there a difference in soaking the hay for a short or long time?

The chapter "All about the hay" will have a close look on the production, quality and ingredients of hay. The next chapter "Fructan" will point out one of the dangerous ingredients in the hay, the fructan. The development of fructan will be examined as well as previous studies done by the chamber of agriculture. The next Chapter "Equine laminitis" points out the disease which could be caused by a high intake of fructan. Chapter 6 will describe the previous experiment performed by the LWK. The new experiment which was done to reduce the fructan amount within the hay is described in >Chapter 7. Chapter 8 points out the outcome of the experiment. The last Chapter will discuss the effectiveness of soaking hay, the alternatives and recommendations. At the end a conclusion and recommendations will be given.

3. All about the hay

As mentioned in the introduction the horses diet contains a high fibre amount. As the domesticated horse is most of the time not able to graze within the winter months, a conserved feed is needed. Therefore an explanation of the two most popular conserved feeds, haylage and hay will be given.

3.1 Haylage

Haylage is conserved feed which has dry matter content between hay and silage. Silage is the feed which is used for cows most of the time. The following table shows the average composition of hay and other high fibre feeds to make it clearer.

Feed	Crude protein (%)	Crude fibre (%)	Digestible energy (MJ DE/kg)	Dry matter (%)	pH
Hay	4.5-10	30-40	7-10	80	
Silage	10	30	10	25	
Haylage	8-14	30-38	9-11.5	55-65	5.3-5.8

Table 1 (Referring to Pilliner 1999)

Haylage is highly palatable and the intake of energy is quite high and rapidly. The substitution of haylage for hay should be on a weight for weight basis, because haylage contains a lot of water and is therefore consequently heavy, so the horse will receive equivalent amounts of energy and protein from a smaller amount of feed. The disadvantage is that the portion will be eaten more quickly because the horse receives less fibre. The right fermentation is important for the quality of the haylage. The following guidelines should be followed:

- The preferable dry matter content is between 55 and 65.
- The ph level should be between 4.5 and 5.8. A lower level is often unpalatable for the horse. A level above will not be acidic enough to prevent potentially lethal micro-organisms developing.
- The ammonia nitrogen level should be less than 5 percent

(Pilliner 1999)

3.2 Production of silage or haylage

The process of conserving silage or haylage contains the fermentation and the resulting reduction of the ph value. Furthermore a CO2-atmosphere is produced as well as metabolic products with an antimicrobial effect and the growth of the osmotic value.

The quality of the outcome depends on the product and the process of conserving. A high concentration of water-soluble carbohydrates (glucose, fructose, etc), high dry matter content (results in a higher osmolarity) and worse buffer attributes are needed ferment-attributes.

The exclusion of oxygen is needed for a successful fermentation process. Therefore an air density packaging (plastic foil around the round bale) of the silage is needed. The fermentation process has six phases:

First phase: During the start of the wither phase at the field a dramatically increase of the lactic acid bacteria can be noticed, especially if the plant material is damaged and plant sap escapes. Other aerobic microorganism increase as well.

Second phase: In this phase the remaining oxygen, in the plastic foil trapped bale is used up within some hours. The reason for that is the breathing process of the plant and also the aerobic spore building.

Third phase: Within one to two days the lactic acid bacteria and other anaerobic germs increase.

Fourth phase: The lactic acid bacteria are at the highest point during the 1-2 weeks of this phase.

Fifth phase: The lactic acid fermentation stops. Either all the fermentable carbohydrates are used up or the critical ph value is reached. The critical ph value makes the growth of “Clostridien” impossible and the silage remains stable. Desirable silage should obtain a full structure of stems and leafs with a pleasant, sourly and aromatic smell. The color should be nearly the same as the initial product.

Sixth phase: Is the so called turnover of the silage. This is happening if the critical ph value has not been reached. A microbial reduction of the lactate and protein and a rising ph level will result in a butyric fermentation and moulding process. A strong yeast population at the beginning of the fermentation process together with a deficient air density results in an after fermentation with acid reduction. Both will result in spoilage of the silage.

Therefore the production of good quality silage depends on several factors and to be successful maximum accuracy is needed. To produce silage for horses’ only one method is successful, the air density packaging with plastics foil. Incoming oxygen will destroy the silage therefore it is necessary to use an open bale as soon as possible. (Schütz 1999)

3.3 Hay production

The conservation method used for the hay production is drying. The plant population, fertilization and the weather during the growth are important factors besides the moment of cutting the grass. A cut before heyday until May, will result in hay with low fibre content but with a high energy and protein amount. The later the cut, the higher is the yield and the fibre content but the lower is the energy and protein amount. (Schütz 1999)

The drying of the hay is done outside on the ground with the help of the sun energy or with a frame (in the old days) or with technical energy (hot air). It is necessary to gain a dry matter percentage of 86 and especial an even drying to prevent the “sweating” of the hay which will result in losing the remaining moisture. For the same reason it is necessary to store the hay either in small rectangle bales or in big round bales under dry circumstances. Remaining residual moisture can result in heat build-up although the circumstances were ideal. The reason for that is the activation of the plant enzymes and “mesophilic microorganisms”, which cause a change in color, the loss of carbohydrates and a reduction of the digestibility of the protein which is called Millard reaction. At 40 degree Celsius the “thermophile microorganism” is supported in their growth. The moisture of the hay and the amount of microorganism correlate in a positive way. Normally the processes will go down with a compensation of the moisture in the hayrick but in extreme cases the hayrick can ignite itself. (Schütz 1999)

The evaluation of the quality of the hay takes place according to the principles of the DLG-Key to assess the hay with the senses. Desirable is a hay which is little discolored, strong (not soft or gentle) and leafy without any impurities and with an aromatically smell. (Bender 2000)

3.4 *Ingredients of hay*

The following table demonstrates the impact of variances which could affect the horses' health. It is important to keep an eye on the quality of the horses feed.

Parameter	**Unit**	**Silage**	**Hay**	**Impact of variance**
Dry Matter(DM) percentage	%	40 – 50	≥ 86	Incomplete or no fermentation process, low storage stability and risk of mould
Crude ash	% of DM	≤ 8		Diseases of the bronchial tract, dust allergy and other diseases
Crude protein	% of DM	≤ 14		
Crude fibre	% of DM	27 - 30		
Fructan	% of DM	< 5,0		Laminitis
Digestable crude protein	g / kg DM	≤ 110		
Digestable energy	MJ DE / kg DM	> 9,5		Possible innapropriate energy care
Fermentation/conservation quality	Mark/Judgement	1 / very good		Loss of feed, low acceptance of the feed, possible diseases
Feed hygiene	CFU/g FS	< 500 mould, < 5.000 yeast		Diseases of the bronchial tract, dust allergy and other diseases
Storage stability	Days	> 3	Non-existent	Higher losses of feed, low acceptance of the feed

Table two (Referring to the chamber of agriculture Lower Saxony)

The **Dry Matter** percentage is what is left after reducing the water from the plant. A high DM percentage indicates a "dry" feed. If the hay has a lower DM percentage than 86% the risk of moulding is high. **Crude ash** is indicated as a percentage of the DM and should be less 8%.

Crude ash could contain calcium or phosphorus which was absorbed by the plant, both are desirable. It could also be sand from the ground which was mixed in the hay during the harvest of the hay. Another possibility is a contamination with twigs which is like the sand not desirable in the hay. If the hay contains a lot of crude ash, the horse could develop a dust allergy which will be described in the following chapter 3.3.The **Feed hygiene** indicates the amount of mould and yeast in the hay. It is determined as CFU (Colony forming units) per gram of the Feed Stuff (FS). The amount should be less than 500 →mould and 5.000 →yeast. Otherwise the risk of developing a dust allergy rises. **Crude protein** and **crude fibre** are again a percentage of DM. **Fructan** is also indicated as a percentage of DM and should be lower than 5%. The fructan will be described more in detail in Chapter 4. The **fermentation quality** should be very good otherwise the horses will not accept the feed and the risk of developing diseases like diarrhoea rises. The **storage stability** means the days the feed could be used. The horses do not like to eat a silage bale which was open for a longer time (3 days).

3.5 Dust allergy

A sign for a health problem of the horse is coughing. The cause of that will be described in the following paragraph.

Cough is a serious symptom for different diseases. It could be bronchitis or an allergy. The Veterinarian checks if it is bronchitis or an allergy. If the veterinarian decided that it is not an infectious disease it is likely to be a cough which is caused by an allergy. The adverse conditions the horse is in can support the cough which can result in a damage of the lungs. It is more likely that older horses develop a dust allergy but also young horses can develop this allergy. The allergy occurs often in stables where the horse are kept inside for 24 hours a day in single boxes, most of the time without a paddock or even a window where fresh air comes in. The air inside the stable is full of dust from the straw and hay. Nevertheless young horses or horses that live in an open stable with 24 hours fresh air can develop an allergy against dust. Different allergens are responsible for the cough, the most common one are the fungal spores in the hay and straw. The fungal spores are much smaller than the sand-particle from the riding arena. Therefore the fungal spores can easily enter the lungs. The fungal spores are very dangerous because even hay of a high quality contains the spores. If the immune system overreacts or an infection is not treaded until its very end, a dust allergy from the hay will be the result. In the final stage of the allergy irreparable damages of the lungs like the pulmonary emphysema will occur. The horse tries to press the air out of the lungs with the help of the abdominal muscles. With every breath some of the air will stay in the alveoli and the lungs over expand itself. If the horse is not treated immediately which means remove the horse from the allergens; the alveoli will be destroyed irretrievable.
As a first treatment it is necessary to soak the hay to wash out the dust. Besides the straw bedding of the stable should be replaced by shavings and additional inhalation could help. (Jürgens 2011)

4. Fructan

The allergy against dust is a problem of high concern to the domesticated horse, but another important factor is the fructan intake. The following Chapter will give an insight into the Fructan.

The horses' diet contains a lot of sugar, much more than the wild living horse was designed to absorb. The human provides all different kinds of supplements and extras like apples or carrots for the horse which have a high concentration of sugar. The grass and hay produced by the human contains also a higher sugar amount than the steppe grass the wild horse was used to. The horses' digestive tract is not able to deal with all the sugar (see Chapter 5.1). That is why the sugar in the plant called fructan could be the cause for a feeding related laminitis. (Bender 2000)

Fructan or Fructose, a Polymer of fructose, is a vegetable reserve carbohydrate, which appears especially in the plants of the temperate region. It is a non- structural carbohydrate as well as glucose, fructose, saccharose and starch. (Dahlhoff 2002)

Within the chloroplast of a plant the photosynthesis occurs. The chloroplast contains the green pigment of the leaf→ the chlorophyll. The chlorophyll is able to produce the glucose with the help of the sunlight. Besides the glucose other sugar types are produced. Every type develops different attributes while forming the long molecular chains, the products are used by the plant for different reasons like energy reserve, energy supply, resistance, protection against drought or frost. Such a sugar type is the fructan. It is a long-chain, water-soluble sugar molecule, which is stored by the plant once there is an overflow of energy. This is the case if a high amount of sunlight hits the plant without the needed (warm) temperature for the growth of the plant. The plant saves the fructan in the root and the stem. A lot of fructan is saved if the plant is under stress like horses keep the plant constantly short or if the plant is cut regularly. The amount of fructan drops if the plant is able to grow unimpeded and therefore uses a lot of energy. The fructan amount within a plant depends on several factors which have an influence on the photosynthesis or the use of carbohydrates and therefore the storage of fructan. (Dahlhoff 2002)The factors will be described in the following parts.

4.1 The different kinds of plants

Ten different plant-families are known where the fructan is common, including the economical important family of the Gramineae, the sweet grass. An analysis of 25 grasses was done by OJIMA and ISAWA (1968). The outcome showed that there was no sort of grass which used a high concentration on fructan and starch as a reserve-carbohydrate. OJIMA and ISAWA divided the 25 grasses into three groups:

- The fructan saving group was called "northern type", which occurs under cooler climate circumstances
- The starch saving group was called "southern type" including mainly grasses which are adjusted to warmer regions
- The intermediate group stored starch as well as saccharose

The fructan amount within the plants of the European region varies considerable. A Study of VON BORSTEL and GRÄßLER (2002) analysed the fructan amount within different sorts of grass like the german ryegrass and the "welsches" ryegrass as well as other sorts of grass. The ryegrass had the highest amount of fructan and the "Wiesenfuchsschwanz" and the "Wiesenlischgras" the lowest amount.
The following table is a simplified version of the outcome of the study:

Grass strain/sort	Fructan amount (%DM) within the year	
	Early	late
german ryegrass, sambin	6,4	7,2
german ryegrass, Anton	8	5,4
german ryegrass, Respect	4,9	6,1
german ryegrass, Edda	6,6	5,4
german ryegrass, Stratos	6,2	8,9
german ryegrass, Gemma	6,9	6,2
"Welsches" ryegrass, Lemtal	6,7	9,7
"Welsches" ryegrass, Lipo	6,8	9,4
Mixture Standart GI	6	9,9
Mixture Standart GIII	5,8	10,9
Average GR and WR	6,6	7,3
Average german ryegrass	6,5	6,5
Average "welsches" ryegrass	6,8	9,6

Table three

The german ryegrass, the “welsches” ryegrass and the two mixtures GI + GIII are the sorts with the highest amount of fructan.
Fructan is an ingredient of crop. The stem and the corn contain the fructan. The following table contains the fructan amount of the corn which is relevant for the horses’ diet.

Sort	Amount of fructan(g/kg DM) in the corn
rye	31
wheat	15
maize	6
barley	4
oat	3

Table four

The fructan amount of the crop straw is low as well as in conserved grass, hay or silage. The fructan level in the fresh material is higher. Dandelion and thistles occur also on meadows for horses and save fructan as well. Leguminous plants like clover or lucerne save starch and saccharose and fructan if any only in slight amounts. (Dahlhoff 2002)

4.2 Daytime and Season

The amount of fructan differs within hours. Studies from WAITE and BOYD (1953), MACKENZIE and WYLAM (1957) and LONGLAND and CAIRNS (2000) discover that the amount rises within the day, the lowest point in the early morning and the highest point in the afternoon. Different studies tried to analyse in which time of the year the amount of fructan is the highest. Unfortunately all of the studies had a different outcome. It is more likely that seasonal influences like temperature, growing season or light intensity which affect the photosynthesis will be the cause for the different outcomes within the year.

4.3 Growing season

The nutrient content of the grass changed within the growing season. As the grass gets older the fibre content raises but the amount of digestible energy and digestible protein is reduced. The loss of the digestible non-structured carbohydrates or the water-soluble carbohydrates is the cause for the loss of digestibility of the grass during the growing season. The energy usage of the plant is the key for the level of fructan. During the development of blossom and seed with a negative energy balance the level of fructan is also low. Again different studies discovered different outcomes.

4.4 Temperature

The relation between the temperature and fructan is negative, that means if the temperature raises the level of fructan decreases and decreasing temperature results in storage of fructan. The temperature in the night has a special importance. Low temperature in the night (app. Freezing point) followed by warm and sunny day results in a high fructan concentration. This happens especially in spring and autumn.

4.5 Light intensity

The intensity of light varies within length of day and the intensity of solar radiation or the thickness of the cloud cover. The fructan production rises if the photosynthesis rises as a result of a high light intensity. The intensity and the duration of the solar radiation have an influence on the photosynthesis and the amount of non-structural carbohydrates. Both factors are influenced by the length of the days and the thickness of the cloud cover.

4.6 Fertilization

The level of fructan varies with the fertilization of the meadow especially with the Nitrogen maintenance. Several authors discover a decrease in the amount of fructan when the Nitrogen Level rises. A fertilization with Nitrogen results in an increase of the growth height where more energy is used for and therefore an increase in the yield. The rising amount of nitrate and crude protein is the cause for a reduction of the fructan level.

4.7 Intensity of using the meadow

Cutting the grass and grazing the grass has an influence on the development of the plants. A growing plant after it was cut is in a stress situation which results in a loss of fructan. If the plant is cut more than twice, the level of fructan decreases from one cut to the other. VON BORSTEL and GRÄßLER (2002) analysed the influence of the moment of cut and the level of fructan. The level of fructan within the third and fourth growth was low. The moment of cut is important but in correlation with the growth period of the plant.

4.8 Summary

Fructan is a reserve-carbohydrate of the plants within the European region. It is stored mainly in the stem of the plant. The level of fructan depends on one hand on the photosynthesis and on the other hand the usage of carbohydrates for growing and respiration, displayed in figure one. The Summary of the influencing factors mentioned before is pictured in figure two which shows the positive or negative impact at the level of fructan.

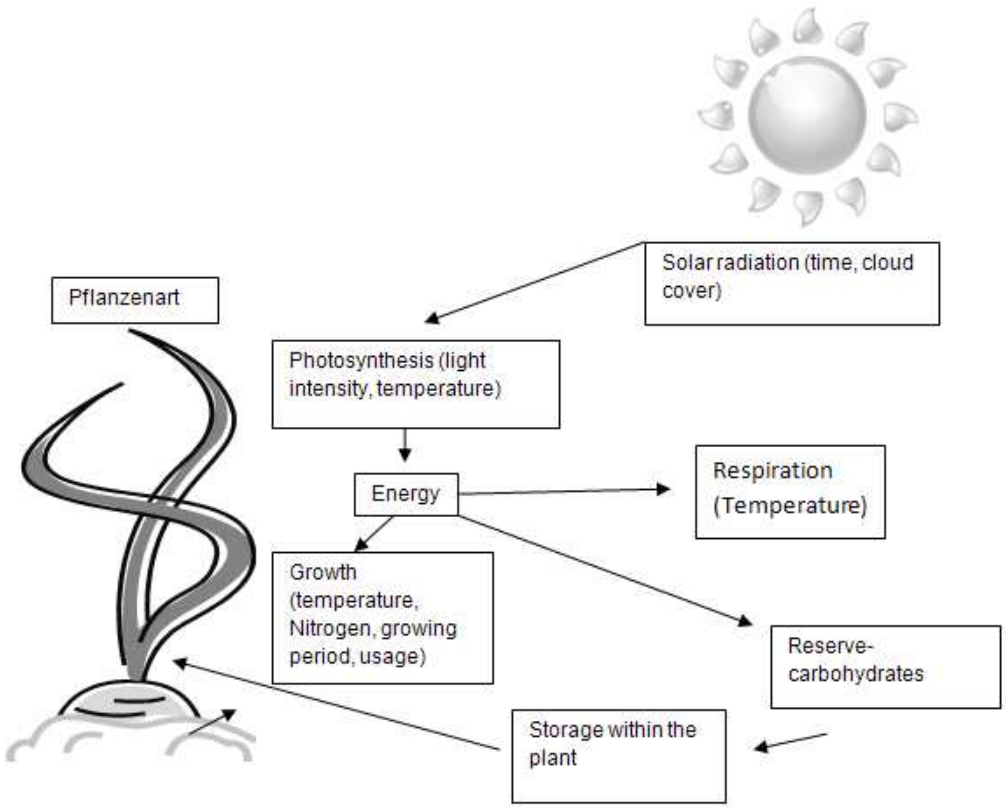

Figure one

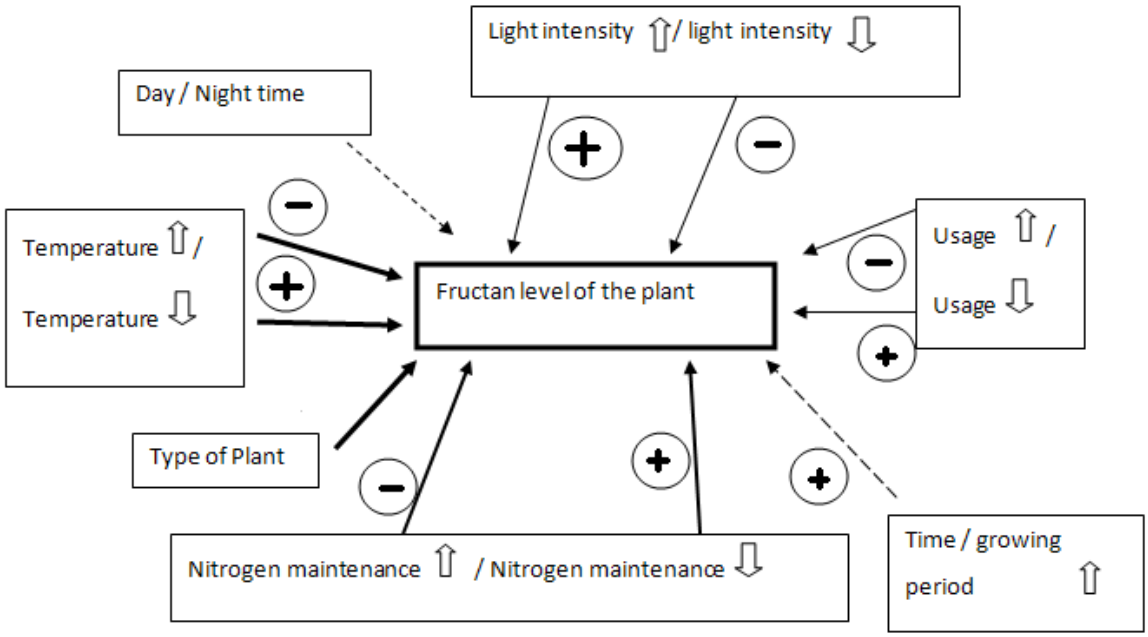

Figure two

5. Equine Laminitis

A high fructan intake can result in a feeding related laminitis. Therefore a description of the digestion of fructan and of laminitis will be given.

5.1 Description of Laminitis

"Laminitis can be a life-threatening condition and prevention is infinitely better than cure."(Pilliner1999, 160)

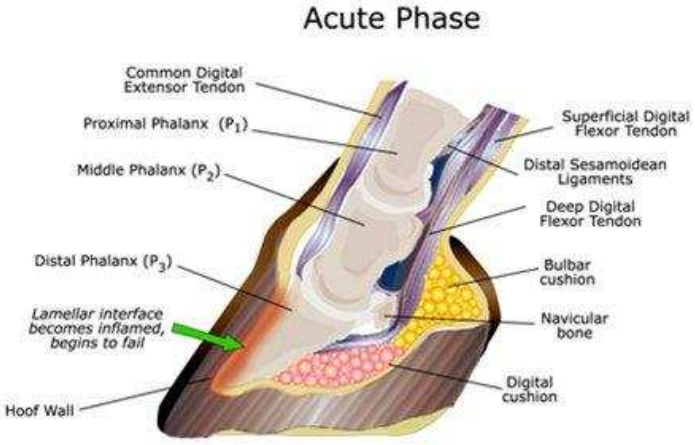

Figure three

Laminitis is in general an inflammation of the sensitive laminae (green arrow on the picture) especially of the blood vessels in the area of the hoof wall. Usually both forelimbs are effected, rarely the hind limbs or all four at the same time. The sensitive lamina is the connection between the wall of the hoof and the coffin bone or Distal Phalanx (p3) in the picture. The connection consists of vessels which are arranged cogged wheeled. These vessels inflame as a reason of processes in the horses metabolism. As a cause of the inflammation the vessels swell. Because of the stable hoof wall surrounding the hoof, the stable sole and the coffin bone inside, the swelling cannot spread. This is intense painful for the horse. If the inflammation persists more than 48hours, which is already called a chronically laminitis, the sensitive laminae will detach between the hoof wall and the coffin bone. As a cause of the detaching and the high pressure from the weight of the horse the following changes in the position of the coffin bone could happen:

- In mild cases a small subsidence of the coffin bone can occur
- A rotation of the coffin bone with subsidence of the top towards the sole
- In some cases a combination of both occurs

(Schmidt 2002)

Furthermore the sole is going to be more and more flat and pressures at the ground. The hoof wall in the front arches towards the insight and is going to be concave. Deep grooves develop around the hoof. In severe cases, the coffin bone penetrates the sole of the hoof. The worst case is called hoof loss. There the hoof capsule detaches from the coffin bone. (Pilliner 1999)

5.2 Causes of laminitis

Laminitis can be caused by different factors: after birth (not losing the placenta), trauma or stress, poisoning or medication. The type of laminitis which will be explained in more detail is the feeding related laminitis. (Schmidt 2002)
The history of the horse shows that the digestive tract from the domesticated horse has not changed a lot since the Eohippus around 50million years ago. The Eohippus had a special pattern of feed intake, the permanent intake of a small amount of feed during the day and night. The feed consists of grass, herbs, leaves, wooden twigs and other plants. The domesticated horse is not able to follow these patterns. It gets only few meals which are high on carbohydrates and protein. (Schmidt 2002)
Within the last 15 years the knowledge of the causes of Equine laminitis has changed. It was believed that a high amount on protein is the cause for a feeding related laminitis, but the processes which results in a laminitis is much more complex. One particular sugar in the grass called fructan is the cause for the laminitis. (Schmidt 2002)

5.3 The processes within the horses' digestive tract

Problematically for the horse is a high amount on fast digestible carbohydrates especially starch and sugar. Again fructan is also sugar. These fast digestible carbohydrates occur either in a too high amount in some feed or are explicit provided for the horse by the owner, as an example as sugar beet pulp. The fructan cannot be digested in the small intestine but is rapidly utilized by microbial species in the large intestine. (Schmidt 2002) If large amounts of starch and fructan reach the hind gut there is a rapid change in the microbial population, associated with the release of toxins and the onset of laminitis. (Frape 1998)The fast digestible carbohydrates serve as food for the acid-producing bacteria that are not desirable. The population of the acid-producing bacteria explodes within some hours, the ph-level of the intestine drops into the sour milieu. That is when all the beneficial bacteria die. Within the walls of the cells of the beneficial bacteria toxics are trapped. When the bacteria die the toxics are released in the blood stream and when the toxics arrive in the hoof a fateful reaction will be the result. A high amount of finest coagulum develop, which preferred to remain at the sensitive laminae. That is the cause of a lack of blood supply through the hoof. Besides the acidosis within the body results in a swelling of the blood vessel which entails a development of the so called shunts. Either way it results in an inflammation of the sensitive laminae. (Schmidt 2002)

6. Previous experiments

The chamber of agriculture in Hannover did already some analysis on the fructan level within a plant. The first analysis shows the difference in the fructan level between 3 cuts of the grass. Therefore different sorts of grass were cut three times per year. The experiment was done at the “Dasselsbruch”. The table will illustrate only some of the sorts to underline the information’s found in the literature about different fructan amounts in different grass sorts and the reduction of fructan in the grass between the different cuts.

	Cut in 2009			Cut in 2010		
Sort	1.	2.	3.	1.	2.	3.
A	17,27	8,83	8,98	17,26	16,31	7,5
B	16,37	8,9	7,2	15,63	17,52	5,79
C	15,98	8,83	6,86	15,68	14,82	6,74
D	11,92	7,08	3,71	15,3	13,46	3,98
E	16,97	8,75	6,19	17,57	18,07	5,54
F	15,27	8,05	4,51	12,22	12,27	4,63

Table five

The next analysis done at the chamber of agriculture was done with fresh grass, hay and haylage. The amount of fructan within the three sorts was analysed.
The first table shows the amount on samples.

Grass	24
Haylage	56
Hay	132
Gesamt	212

Table six

The next figure shows the diversification.

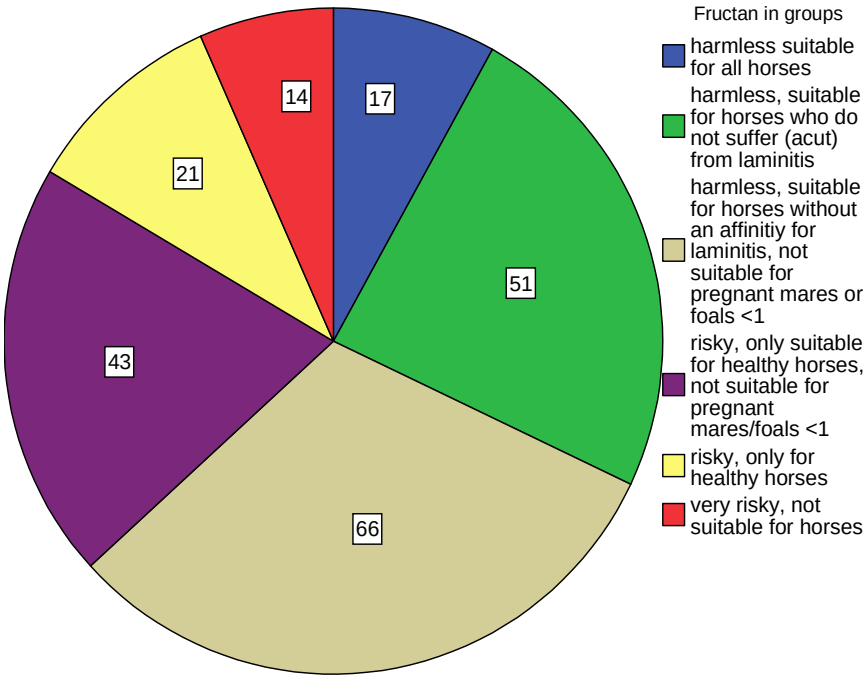

Figure three

The pie shows that only 17 samples can be used without hesitation. (The classification of the samples is explained in Chapter 6.2 Setup of the experiment)The other 195 samples were not suitable for horses that are in danger or already suffering from laminitis. 14 samples were very risky and not suitable for any horse. The next graph will show how these numbers fit to the sorts namely grass, haylage or hay.

Type of the sample * Fructan in groups

		Fructan in Groups						
		harmless suitable for all horses	harmless, suitable for horses who do not suffer (acute)from laminitis	harmless, suitable for horses without an affinity for laminitis, not suitable for pregnant mares or foals <1	risky, only suitable for healthy horses, not suitable for pregnant mares/foals <1	risky, only for healthy horses	very risky, not suitable for horses	Total
Type of the sample	Grass	0	5	3	6	1	9	24
	Haylage	10	11	17	8	8	2	56
	Hay	7	35	46	29	12	3	132
Total		17	51	66	43	21	14	212

Table seven

To draw an easy and clear picture the outcome of the table can be divided into two groups: harmless and risky. It shows that out of 24 grass samples 16 (67%) can be seen as risky and only 8 (33%) as harmless. Two out of three grass samples have a risky fructan level. 88 (67%) samples of hay can be called harmless and 44 (33%) samples are risky. That means that one out of three samples has a risky fructan level. In haylage 38(68%) are harmless and 18(32%) are risky. Also one third out of three is risky. (It is important to have a close look at the classification the samples named “harmless” are only harmless for healthy horse without acute or an affinity for laminitis and some harmless samples are not suitable for pregnant mares and foals younger than one year)

The study included only two hay samples which were soaked. The outcome is displayed in the following table.

		Fructan
Hay A	not treated	5,3
Hay A	soaked	2,3
Hay B	not treated	4,1
Hay B	soaked	1,5

Table eight

This is a first indication that soaking hay reduces the fructan level in the hay. The question which needed to be answered is how long must the hay been soaked for the best outcome? The following chapter will describe the outline and the chapter after the outcome of the experiment which was done to answer this question.

6. The Experiment

This chapter will describe the set up of the experiment the following chapter the outcome of the experiment.

6.1 Aim of the experiment

The experiment will show if there is a difference between the time the hay is soaked. For horse owners it is not practicable to spend a lot of time with soaking hay for the horses. That is why the two timeframes were chosen for the experiment. To soak the hay for one hour could be easily done during mucking out or starting to feed the other horses. Twelve hours is also easily been done while soaking the hay overnight.

6.2 Set up of the experiment

The experiment will show if there is a difference in soaking hay for one hour and for twelve hours. Therefore different hay samples were collected. In total 6 different samples were collected. Every sample was divided into four parts. A1 till A4. A1 was soaked in water for 30 Minutes, A2 for one hour, A3 was soaked for twelve hours and A4 was not treated. Four haylage samples were collected as well but not treated.

<u>The materials:</u>
Hay and haylage samples, weighing device, plastic bags, closures, pen and labels

<u>Preparation of the samples</u>
First of all the hay samples needed to be collected. Therefore different farmers were asked to participate and to spend a sample. Some of them were willing to spend a sample and also interested in the findings. The next step was to divide every sample into four parts of 500gram. Done that, the samples needed to be soaked. Therefore big tubs were used. The samples of group 1 were soaked for 30 minutes. After that the samples had to go into the fridge directly so that no outside circumstances could influence the sample. The same was done with the samples of group 2 one hour and group three 12 hours. The samples of group 4 were not treated.
Before the samples could be analysed it was necessary to create a list with excel. (Annex 1)

<u>Preparation at the laboratory</u>
One day all the samples were taken to the Laboratory of the Chamber of Agriculture “Dasselsbruch” in Lower Saxony. There the samples had to dry for 24hours. First the samples had to be weighed in. A metal bowl was used. The bowl was put on the weigh device and it needed to be tare so that the weight device does not calculate the weight of the bowl. The hay was added to the bowl and it was important to spread the hay over the whole bowl to secure that the sample can dry completely. If the sample would not be spread some parts would not dry completely and it would not be possible to cut them with the cutting machine. The so called “in weight” was written down in the Excel List and the sample was put into the oven. After all the samples were weight and set into the oven, the oven was turned on. The samples had to be in the oven for twenty-four hours at 80 degree.

After twenty-four hours it was necessary to weight the samples again to see how much moisture was gone. Again the samples were weight but it was important to take only one sample out of the oven and to weight it directly because otherwise the sample would absorb too much moisture from the air. The other samples had to remain in the oven which was still switched on. All the samples had to be weight which was called “weight out”. The weight was written down on the excel list. With the help of the list the dry matter content was calculated. The next step was to cut the samples with the cutting machine. Therefore one sample was taken to the machine and three to four hands of the sample were cut by the machine into “hay powder”. After every cutting process the main parts of the machine had to be cleaned.
That was to prevent the mixing of the samples. Every sample was stored in a plastic bag and labelled. After all the samples were cut and labelled the samples were stored in the laboratory. The analysis of the samples was done by Hermann Pommerien.
The method used to analyse the hay samples is called Near Infrared
Reflection Spectroscopy. The process of analysing the fructan with the NIRS was developed by the Julius Kühne Institut in Braunschweig, Germany.
The NIRS uses a lamp which shines through the hay powder sample. Every ingredient of the sample like protein for example throws a different light back to the machine. The machine converts the light into a special number code and sends the code to the computer. The computer converts the code into an output for example 4% of protein were in the sample. All the values are transferred to the computer and processed with Excel.

Classification of the fructan level

The fructan levels in the samples were classified by the “AG FUKO”. The following table explains the different classifications.

Description	Fructan Level as a % of DM
harmless suitable for all horses	0-1
harmless, suitable for horses who do not suffer (acute)from laminitis	1,1-3
harmless, suitable for horses without an affinity for laminitis, not suitable for pregnant mares or foals <1	3,1-5
risky, only suitable for healthy horses, not suitable for pregnant mares/foals <1	5,1-7,5
risky, only for healthy horses	7,6-10
very risky, not suitable for horses	>10

Table nine

7. The outcome of the experiment

The data from the analyses was collected in an Excel sheet. These data needed to be processed with SPSS. SPSS is used to see if there is a significant difference between the different time periods the hay was soaked. As mentioned before the fructan level in the hay depends on several factors like type of grass or day of cut. The evaluation is based on the experiment done and the facts out of the analysis with SPSS.
The first graph shows the segmentation of the two feeds namely hay and haylage. In total 4 haylage samples and 32 hay samples were collected.

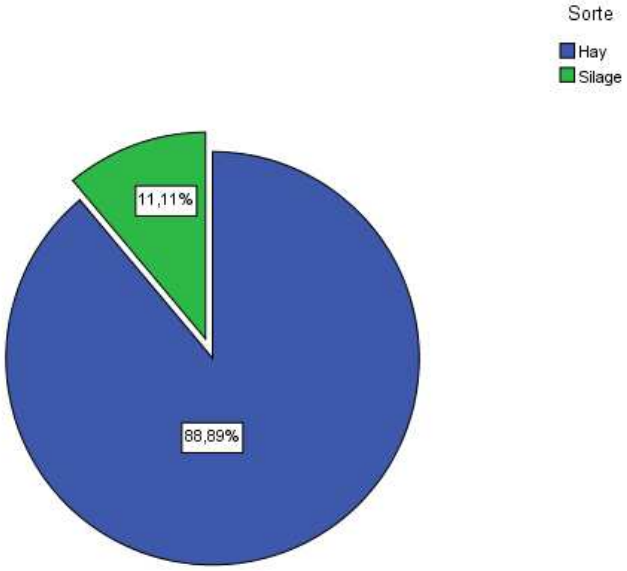

Figure four

Hay Sort	Treatment			
	not treated	soaked 30 minutes	soaked 1 hour	soaked 12 hours
A Hay	1	1	0	1
B Hay	1	1	1	1
C Hay	1	1	2	1
D Hay	1	1	2	1
E Hay	1	1	1	1
F Hay	1	1	0	1
G Hay	1	1	1	1
H Hay	1	1	1	1
I Haylage	4	0	0	0

Table ten

Fructan level	Frequency	Percent	Reliable percentage	Cumulated percentage
harmless, suitable for all horses(0-1)	4	12,5	12,5	12,5
harmless, suitable for horses who do not suffer (acute)from laminitis(1,1-3)	8	25,0	25,0	37,5
harmless, suitable for horses without an affinity for laminitis, not suitable for pregnant mares/foals <1 year(3,1-5)	13	40,6	40,6	78,1
risky, suitable for healthy horses, not suitable for pregnant mares/foals<1year(5,1-7,5)	6	18,8	18,8	96,9
risky, only for healthy horses (7,6-10)	1	3,1	3,1	100,0
Total of samples	32	100,0	100,0	

Table eleven

The table includes all the 32 hay samples and how high the fructan level is. As the table shows 25 samples had a fructan level within the harmless groups (0-5%fructan). 25 samples are 78 % of the total amount of 32 samples. 7 samples had a fructan level higher than 5% (5,1-10%) which means risky for horses.

The following table will show how the samples were treated to get this outcome.

		Fructan in Groups					
		harmless, suitable for all horses(0-1)	harmless, suitable for horses who do not suffer (acute)from laminitis(1,1-3)	harmless, suitable for horses without an affinity for laminitis, not suitable for pregnant mares/foals <1 year(3,1-5)	risky, suitable for healthy horses, not suitable for pregnant mares/foals<1year(5,1-7,5)	risky, only for healthy horses (7,6-10)	Total
Treatment	Not treated	1	2	4	1	0	8
	soaked 30 min	1	1	2	3	1	8
	soaked 1 hour	0	2	6	0	0	8
	soaked 12 hours	2	3	1	2	0	8
							32

Table twelve

In total every treatment group had 8 hay samples. To make it more obvious the following graph is used.

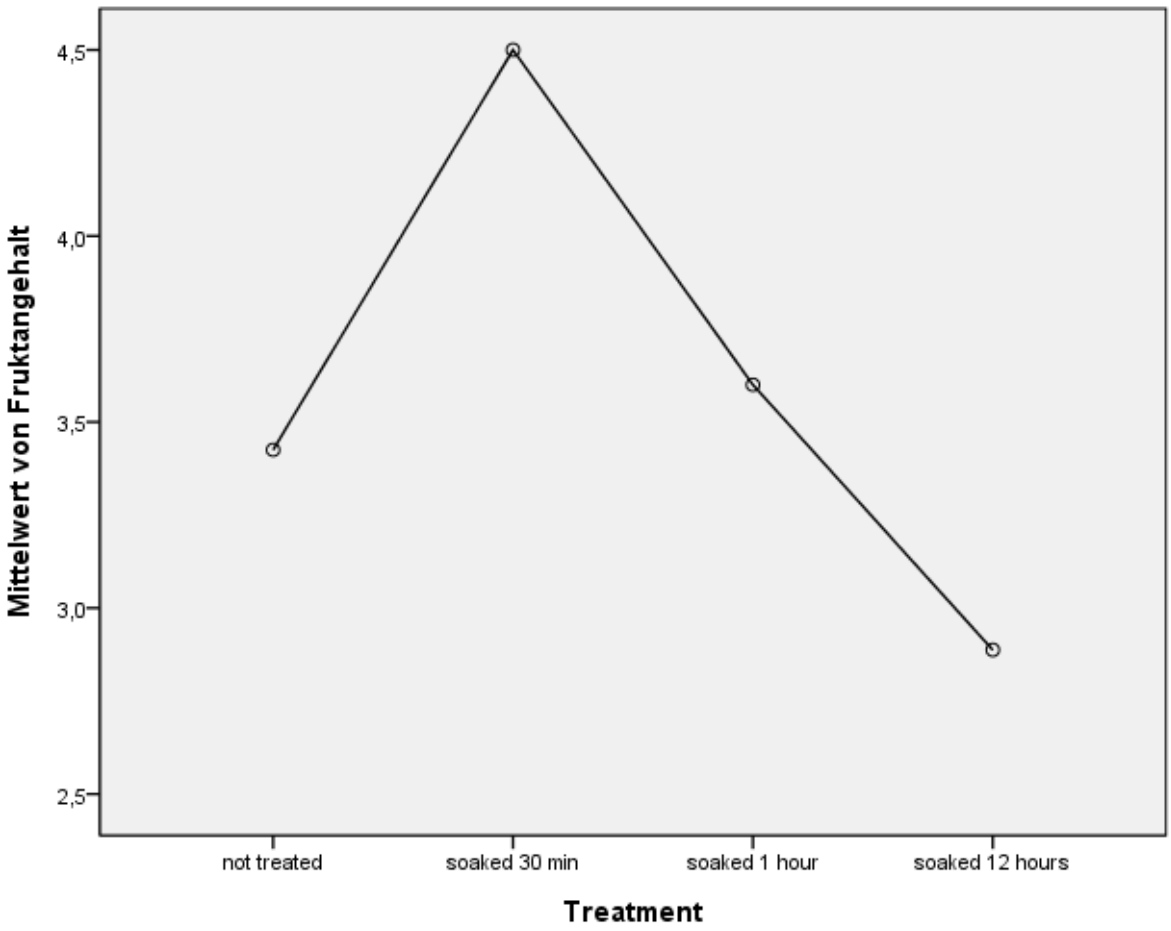

Figure five

The fructan level rises after 30 minutes of soaking but than a downtrend can be recocnised. The next test is the “Kruskal Wallis” test to show if there is a significant difference between the four different treatments(soaking 30 min, 1 hour, 12 hours and untreated) and the fructan level in groups(harmless till risky).

Statistik für Test(a,b)

	Fructan in Groups
Chi-Quadrat	2,976
df	3
Asymptotische Signifikanz	,395

a Kruskal-Wallis-Test
b Gruppenvariable: Treatment

Table thirteen

The outcome (p-value=.395) shows that there is no significant difference.

The following table shows the different sample groups. The capital letters define a group of the same hay sample which was divided into several samples which again were treated in the mentioned ways.

Samplegroup	Fructan level	Treatment			
		not treated	soaked 30 min	soaked 1 hour	soaked 12 hours
A	0		1		
	0,4	1			
B	1				1
	1,6	1			
	2,9		1		
	3,6			1	
C	2,5				1
	3,8	1		1	
	4,2			1	
	5,2		1		
D	1,9				1
	2,5	1			
	3			1	
	3,3		1		
E	3,4				1
	4,1	1			
	4,4			1	
	4,6			1	
	5,1		1		
F	6,5				1
	6,8	1			
	8,9		1		
G	1,2				1
	3			1	
	3,5	1	1		
H	4,7	1			
	4,8			1	
	6,6				1
	7,1		1		
I	0	2			
	1,3	1			
	1,5	1			

Table fourteen

Group A till H are the hay groups. Group I was the Haylage. Group b till H was soaked for 12 hours. It can be said that in 6 out of 7 groups the lowest fructan level was after 12 hours of soaking.

The last table shows that the fructan level of the haylage is harmless than means below 5%.

Fructan in groups

Fructan level	Frequency	Percent	Reliable percentage	Cumulated percentage
harmless, suitable for all horses(0-1)	2	50,0	50,0	50,0
harmless, suitable for horses who do not suffer (acute)from laminitis(1,1-3)	2	50,0	50,0	100,0

Table fifteen

8. Discussion / Conclusion

Discussion

The literature was talking about the reduction of fructan in the hay with the help of soaking the hay. The aim of the study was to discover if there is a difference in soaking hay for a short or a long time. SPSS analysed that there is no significant difference between the time of soaking and the fructan level in the hay. Nevertheless the pure figures show that there is a reducing in the level of fructan. Six out of seven hay groups had the lowest fructan amount after 12 hours of soaking.

The literature is also talking about the sugar in the horses' diet. A domesticated horse is fed with a lot of sugar via the supplements, goodies and the hay. As fructan is a cause of feeding related laminitis, it is important to reduce the sugar from the horses' diet. This can be done by reducing the supplements or buying sugar free supplements and reducing the goodies. The fructan level in the grass can be reduced by soaking the hay for 12 hours. Another possibility is of course to buy or produce hay with a low fructan level. The sorts of grass as well as the time of cut are playing an important role to get hay with a low fructan level. The experiment of the LWK discovered that a low fructan level can be achieved by cutting the grass more than two times. Nevertheless to get a third cut the weather circumstances are very important as well as the region were the hay is produced and if the meadow is used for grazing or only for producing hay. Other factors like the type of grass play also an important role. For the ordinary horse owner it is not feasible to consider all the circumstances to get hay with a low fructan level. Besides not all the horse owners produce own hay. The ordinary horse owner is depending on the people producing hay. These people are more likely to not spend much time on thinking about the fructan level within the hay because the only thing that counts is to sell the hay as soon as possible for the best price. The awareness of the dangerousness of fructan has not reached the ordinary horse owner. Only the once owning a horse suffering from laminitis are forced to think well about the ingredients of the feed for the horse. For the horse owner it is much cheaper to test the hay than having a full treatment against laminitis. As the prices for a treatment of laminitis are depending on the seriousness one example will be given to calculate the difference between treatment and prevention.

	Price
Hay analysis	35€
hay (4kilo)	0,88
water 30lt.	/
tub (60liter)	4,25
time	10minutes + 12 hours
Veterinarian	appr.443€

Analysing one hay sample costs 35€. A membership at the AG FUKO costs 50€ and 3 analysis of hay per year are free. The price for the hay is calculated as follows one bale of 18 kilo costs at the moment 4€. For one portion 4kilo are need. The water is free because it comes from an own water well. A tube costs at the hardware store 4,25€. Time needed is approximately 10 minutes to prepare every think and than 12 hours for soaking the hay. To feed a horse of 400 kg for one year with a daily portion of 8kilo hay costs: 640€ +analysis 35€+a tube = 679,25€.
The Veterinarian costs: whole treatment of one Vet → 323€ + another Vet making two radiographs with analysis etc. 120€.

The Veterinarian costs were for one laminitis period if the diet of the horse is not changed another period could appear and again the costs. An important aspect is the time the horse needs to heal. That goes up to one year.

The horse used for the example had its laminitis half a year ago. At the moment the horse is ridden outside for app. one hour in walk. The horse is allowed to trot for 5 minutes but no canter is allowed. The horse should always walk straight no circles or riding in the arena because it is not useful for the healing process. This healing process will take another half a year and then another Veterinarian consult for 120€ is needed to see if the hoof is able to cope with the stress of the horse being ridden under normal conditions. This example horse was suffering from a mild case of laminitis. The severe once will take much more money and time. The example horse has no special shoeing the farrier is treating the horse every 8 weeks like it would be normally. Special shoes and treatment every six weeks how it is needed for a severe laminitis will cost much more. Therefore it is much cheaper to prevent a laminitis than treating it.

At the moment the price for hay is very high. One small bale costs 4€ compared to the last years 2,50€. The result is most of the time the horse owner looks more on buying cheap hay than buying the best quality. For the farmers who harvest the hay and sell it, it could be a competitive advantage to sell hay with a low fructan level. It is also an advantage for the feeding industry to produce alternative feed for hay which has a low fructan level.

Another alternative of feeding soaked hay could be to feed haylage. The previous experiment discovered that one out of three samples had a low fructan level. The haylage of the new experiment had all four a low fructan level. It needs to be further investigated if haylage could be an alternative of soaked hay because haylage has a high amount on crude protein and also a higher amount on digestible energy. It needs to be further investigated if that is useful for a horse suffering from laminitis.

Conclusion

In the experiment 8 groups of hay (every group consist of a different sort of hay) and one group of haylage was analysed. One group was not tested for 12 hours. The outcome is that out of 7 hay groups, 6 had the lowest fructan level after 12 hours of soaking. The main research question: “Does soaking hay reduce the fructan amount in the hay?”can be answered with yes. One of the sub questions was if there is a difference in soaking the hay for a short or long time? The answer is yes. The fructan level rises after 30 minutes of soaking but at the end it drops after 12 hours of soaking. This phenomenon needs further investigation. The dangerous ingredients in the hay are the fructan and the dust. As mentioned before both can be reduced with soaking the hay. It is for sure that soaking the hay for 12 hours reduces the fructan level in the hay.

As a recommendation it would be useful to perform another experiment with more samples. The best outcome will be gained if the experiment is done from the really beginning so that all the factors influencing the fructan level are known. That means growing the grass so the sort of grass is known, cutting the grass and later harvesting the hay and then performing the experiment again. It will also demonstrate f it was a coincidence that the fructan level raises after 30 minutes of soaking or not.

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Annex 1

lfd. Nr.	Betrieb	Futterart	Tierart	Ziel TVerd	Ziel FVerd	Einwaage	Auswaage	TMk	Ziel TM	Asche	XP	XF	XL	XZ	ELOS	EULOS	Fruktan	Bewertung	Eignung
1	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	218,60	55,00	24,4	>86	11,5	12,8	29,9	1,3	4,9	50,6	41,6	1,8	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
2	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	181,80	49,70	26,4	>86	14,3	14,6	30,7	1,3	0,5	55,4	35,2	0,0	unbedenklich	empfohlen für alle Pferde
3	unbehandelt	Heu	Pferd	entfällt	entfällt	95,80	83,40	87,1	>86	12,6	13,3	27,8	1,3	4,1	50,9	39,2	0,4	unbedenklich	empfohlen für alle Pferde
4	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	297,50	94,50	30,6	>86	11,7	6,3	29,4	1,3	5,3	21,7	65,6	1,1	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
5	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	311,70	68,00	21,3	>86	10,8	8,7	32,9	1,3	3,5	29,1	62,9	1,0	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
6	unbehandelt	Heu	Pferd	entfällt	entfällt	105,70	92,60	87,6	>86	12,1	10,8	28,5	1,3	6,6	30,3	56,2	1,6	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
7	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	283,10	66,90	23,0	>86	7,9	10,0	34,3	1,3	7,9	42,7	58,3	3,8	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
8	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	252,40	55,50	21,4	>86	7,8	10,2	35,7	1,3	4,5	37,7	62,0	2,5	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
9	unbehandelt	Heu	Pferd	entfällt	entfällt	118,40	106,80	90,2	>86	8,1	10,5	31,9	1,3	11,8	46,2	52,7	3,8	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
10	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	324,10	86,00	25,7	>86	7,9	12,5	33,1	1,3	8,2	45,9	52,1	2,0	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
11	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	238,50	49,40	20,2	>86	7,2	9,7	37,0	1,3	7,1	38,4	62,3	1,9	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
12	unbehandelt	Heu	Pferd	entfällt	entfällt	105,80	92,90	87,8	>86	7,6	11,5	32,2	1,3	13,4	46,5	51,6	2,5	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
13	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	234,10	63,30	26,2	>86	6,9	9,8	34,2	1,3	9,3	43,3	58,7	4,4	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
14	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	295,90	63,70	21,0	>86	6,8	9,6	36,6	1,3	6,1	41,9	62,9	3,4	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
15	unbehandelt	Heu	Pferd	entfällt	entfällt	113,70	99,50	87,5	>86	6,9	8,7	35,0	1,3	12,4	45,3	59,8	4,1	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
16	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	211,70	60,00	27,4	>86	6,8	11,0	31,2	1,3	9,3	47,7	53,9	7,1	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
17	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	263,10	53,10	19,7	>86	6,2	10,2	33,3	1,3	8,5	42,9	59,0	6,5	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
18	unbehandelt	Heu	Pferd	entfällt	entfällt	101,30	88,80	87,7	>86	5,9	8,8	32,1	1,3	13,8	48,6	55,1	6,8	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
19	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	295,70	70,80	23,3	>86	9,5	9,9	35,7	1,3	4,0	27,6	66,1	1,5	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
20	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	313,00	57,20	18,0	>86	10,3	9,6	37,0	1,3	2,1	25,0	68,6	1,2	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
21	unbehandelt	Heu	Pferd	entfällt	entfällt	102,30	90,20	88,2	>86	8,5	11,3	33,5	1,3	7,9	29,1	65,3	3,5	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
22	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	258,00	64,30	24,2	>86	7,0	6,7	37,5	1,3	6,8	37,6	65,1	4,8	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
23	12 std eingeweicl	Heu	Pferd	entfällt	entfällt	441,60	104,60	23,0	>86	6,8	6,0	37,5	1,3	4,4	33,5	70,0	6,6	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
24	unbehandelt	Heu	Pferd	entfällt	entfällt	84,90	74,90	88,2	>86	7,7	7,6	35,9	1,3	7,5	37,9	64,4	4,7	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
25	unbehandelt	Silage	Pferd	329	529	235,20	144,50	62,2	40 - 50	14,3	16,8	25,6	2,1	4,2	53,3	30,8	0,0	unbedenklich	empfohlen für alle Pferde
26	unbehandelt	Silage	Pferd	307	541	224,60	131,60	56,6	40 - 50	14,3	17,1	26,1	2,1	5,6	58,0	23,7	0,0	unbedenklich	empfohlen für alle Pferde
1	unbehandelt	Silage	Pferd	412	496	198,6	164,8	83,1	40 - 50	8,9	16,4	29,9	2,1	3,7	56,5	40,7	1,3	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
2	30 min eingeweic	Heu	Pferd	entfällt	entfällt	246,6	73,6	28,8	>86	8,5	4,6	35,6	1,3	7,5	41,5	65,1	7,1	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
3	30 min eingeweic	Heu	Pferd	entfällt	entfällt	323	74,3	22,4	>86	10,9	11,0	33,9	1,3	5,9	36,4	61,5	3,5	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
4	30 min eingeweic	Heu	Pferd	entfällt	entfällt	254,5	70,8	26,9	>86	6,5	9,2	30,7	1,3	13,2	51,1	56,3	8,9	riskant	für Pferde nicht zu empfehlen
5	30 min eingeweic	Heu	Pferd	entfällt	entfällt	252,1	67,3	25,8	>86	8,1	12,0	32,9	1,3	9,7	46,0	56,6	3,3	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
6	30 min eingeweic	Heu	Pferd	entfällt	entfällt	248	144,9	55,5	>86	16,0	14,5	28,2	1,3	0,8	55,1	36,5	0,0	unbedenklich	empfohlen für alle Pferde
7	30 min eingeweic	Heu	Pferd	entfällt	entfällt	273,8	71,5	25,3	>86	7,9	9,8	34,8	1,3	8,9	50,7	58,7	5,2	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
8	30 min eingeweic	Heu	Pferd	entfällt	entfällt	313,4	88	27,1	>86	7,9	9,1	35,3	1,3	7,9	48,1	60,3	5,1	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
9	30 min eingeweic	Heu	Pferd	entfällt	entfällt	374,8	108,2	27,9	>86	11,7	8,1	29,7	1,3	6,8	33,3	60,9	2,9	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
10	unbehandelt	Silage	Pferd	242	597	256,6	104,9	40,6	40 - 50	9,6	17,5	27,7	2,1	4,2	58,7	37,4	1,5	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
11	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	383,6	115,2	29,0	>86	8,5	4,6	36,8	1,3	5,8	40,6	66,1	7,1	riskant	empfohlen für gesunde Pferde bei Zufütterung von fruktanarmer Futter-TM, nicht für tragende Stuten und Fohlen < 1 Jahr
12	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	355,4	76,7	21,1	>86	12,0	10,7	33,7	1,3	4,2	35,3	59,6	3,0	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
13	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	341,8	91,5	25,9	>86	7,5	9,7	32,0	1,3	10,4	52,0	54,9	7,6	riskant	für Pferde nicht zu empfehlen
14	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	330,4	86,8	25,4	>86	8,6	12,3	32,7	1,3	8,2	50,6	51,7	3,0	unbedenklich	empfohlen für Pferde, die nicht akut an Hufrehe erkrankt sind
15	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	346,4	82,1	23,0	>86	15,0	13,9	27,7	1,3	2,1	54,8	35,7	0,4	unbedenklich	empfohlen für alle Pferde
16	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	296	73,7	24,2	>86	8,5	9,8	34,1	1,3	7,7	46,6	57,7	4,2	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
17	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	342,7	94,5	26,7	>86	8,2	11,3	32,8	1,3	9,2	50,7	56,0	4,6	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr
18	1 std eingeweicht	Heu	Pferd	entfällt	entfällt	314	80,5	24,8	>86	11,1	10,1	31,6	1,3	6,6	39,3	56,2	3,6	unbedenklich	empfohlen für Pferde ohne Neigung zu Hufrehe, nicht für tragende Stuten und Fohlen < 1 Jahr

Annex 2 SPSS

Type of the sample

	Beobachtetes N	Erwartete Anzahl	Residuum
Grass	24	70,7	-46,7
Haylage	56	70,7	-14,7
Hay	132	70,7	61,3
Gesamt	212		

Fructan in groups

	Beobachtetes N	Erwartete Anzahl	Residuum
harmless suitable for all horses	17	35,3	-18,3
harmless, suitable for horses who do not suffer (acut)from laminitis	51	35,3	15,7
harmless, suitable for horses without an affinitiy for laminitis, not suitable for pregnant mares or foals <1	66	35,3	30,7
risky, only suitable for healthy horses, not suitable for pregnant mares/foals <1	43	35,3	7,7
risky, only for healthy horses	21	35,3	-14,3
very risky, not suitable for horses	14	35,3	-21,3
Gesamt	212		

Statistik für Test

	Type of the sample	Fructan in groups
Chi-Quadrat(a,b)	87,094	63,434
df	2	5
Asymptotische Signifikanz	,000	,000

a Bei 0 Zellen (,0%) werden weniger als 5 Häufigkeiten erwartet. Die kleinste erwartete Zellenhäufigkeit ist 70,7.
b Bei 0 Zellen (,0%) werden weniger als 5 Häufigkeiten erwartet. Die kleinste erwartete Zellenhäufigkeit ist 35,3.

Statistiken

		Type of the sample	Fructan in groups
N	Gültig	212	212
	Fehlend	6	6

Häufigkeitstabelle

Type of the sample

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	Grass	24	11,0	11,3	11,3
	Haylage	56	25,7	26,4	37,7
	Hay	132	60,6	62,3	100,0
	Gesamt	212	97,2	100,0	
Fehlend	System	6	2,8		
Gesamt		218	100,0		

Fructan in groups

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	harmless suitable for all horses	17	7,8	8,0	8,0
	harmless, suitable for horses who do not suffer (acut)from laminitis	51	23,4	24,1	32,1
	harmless, suitable for horses without an affinitiy for laminitis, not suitable for pregnant mares or foals <1	66	30,3	31,1	63,2
	risky, only suitable for healthy horses, not suitable for pregnant mares/foals <1	43	19,7	20,3	83,5
	risky, only for healthy horses	21	9,6	9,9	93,4
	very risky, not suitable for horses	14	6,4	6,6	100,0
	Gesamt	212	97,2	100,0	
Fehlend	System	6	2,8		
Gesamt		218	100,0		

Kreuztabellen

Verarbeitete Fälle

	Fälle					
	Gültig		Fehlend		Gesamt	
	N	Prozent	N	Prozent	N	Prozent
Type of the sample * Fructan in groups	212	97,2%	6	2,8%	218	100,0%

Type of the sample * Fructan in groups Kreuztabelle

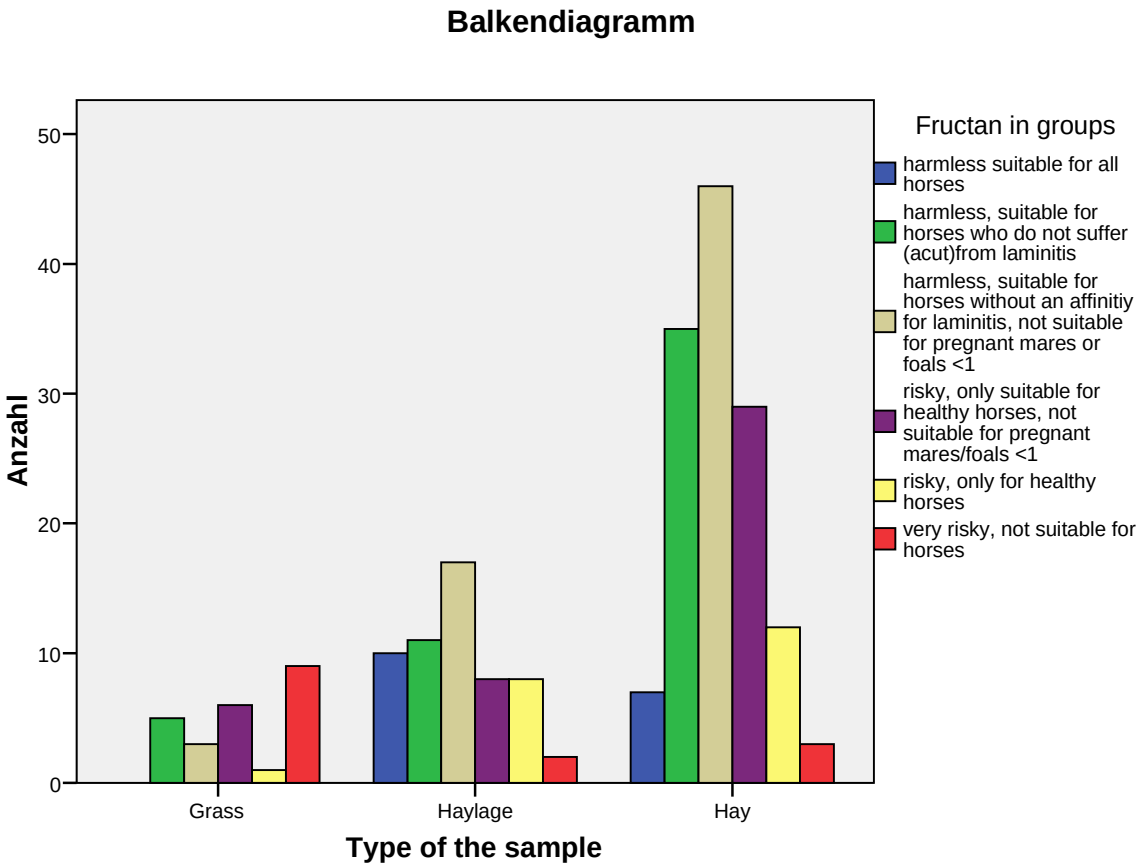
Anzahl

		Fructan in groups						
		harmless suitable for all horses	harmless, suitable for horses who do not suffer (acut)from laminitis	harmless, suitable for horses without an affinitiy for laminitis, not suitable for pregnant mares or foals <1	risky, only suitable for healthy horses, not suitable for pregnant mares/foals <1	risky, only for healthy horses	very risky, not suitable for horses	Gesamt
Type of the sample	Grass	0	5	3	6	1	9	24
	Haylage	10	11	17	8	8	2	56
	Hay	7	35	46	29	12	3	132
Gesamt		17	51	66	43	21	14	212

Chi-Quadrat-Tests

	Wert	df	Asymptotische Signifikanz (2-seitig)
Chi-Quadrat nach Pearson	56,693(a)	10	,000
Likelihood-Quotient	41,182	10	,000
Zusammenhang linear-mit-linear	8,470	1	,004
Anzahl der gültigen Fälle	212		

a 6 Zellen (33,3%) haben eine erwartete Häufigkeit kleiner 5. Die minimale erwartete Häufigkeit ist 1,58.


Balkendiagramm
Anzahl
50
40
30
20
10
0
Grass
Haylage
Hay
Type of the sample
Fructan in groups
harmless suitable for all horses
harmless, suitable for horses who do not suffer (acut)from laminitis
harmless, suitable for horses without an affinitiy for laminitis, not suitable for pregnant mares or foals <1
risky, only suitable for healthy horses, not suitable for pregnant mares/foals <1
risky, only for healthy horses
very risky, not suitable for horses

Häufigkeiten

Statistiken

Fructan in groups

N	Gültig	32
	Fehlend	0

Fructan in groups

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	harmless, suitable for all horses(0-1)	4	12,5	12,5	12,5
	harmless,suitable for horses who do not suffer (acut)from laminitis(1,1-3)	8	25,0	25,0	37,5
	harmless, suitable for horses without an affinity for laminitis, not suitable for pregnant mares/foals <1 year(3,1-5)	13	40,6	40,6	78,1
	risky,suitable for healthy horses, not suitable for pregnant mares/foals<1year(5,1-7,5)	6	18,8	18,8	96,9
	risky,only for healthy horses (7,6-10)	1	3,1	3,1	100,0
	Gesamt	32	100,0	100,0	

Kreuztabellen

Verarbeitete Fälle

	Fälle					
	Gültig		Fehlend		Gesamt	
	N	Prozent	N	Prozent	N	Prozent
Treatment * Fructan in groups	32	100,0%	0	,0%	32	100,0%

Treatment * Fructan in groups Kreuztabelle

Anzahl

		Fructan in groups					
		harmless, suitable for all horses(0-1)	harmless, suitable for horses who do not suffer (acute)from laminitis(1,1-3)	harmless, suitable for horses without an affinity for laminitis, not suitable for pregnant mares/foals <1 year(3,1-5)	risky, suitable for healthy horses, not suitable for pregnant mares/foals<1year(5,1-7,5)	risky, only for healthy horses (7,6-10)	Gesamt
Treatment	not treated	1	2	4	1	0	8
	soaked 30 min	1	1	2	3	1	8
	soaked 1 hour	0	2	6	0	0	8
	soaked 12 hours	2	3	1	2	0	8
Gesamt		4	8	13	6	1	32

First Anova test:

H0: There is no significant difference between the treatment groups and the fructan level

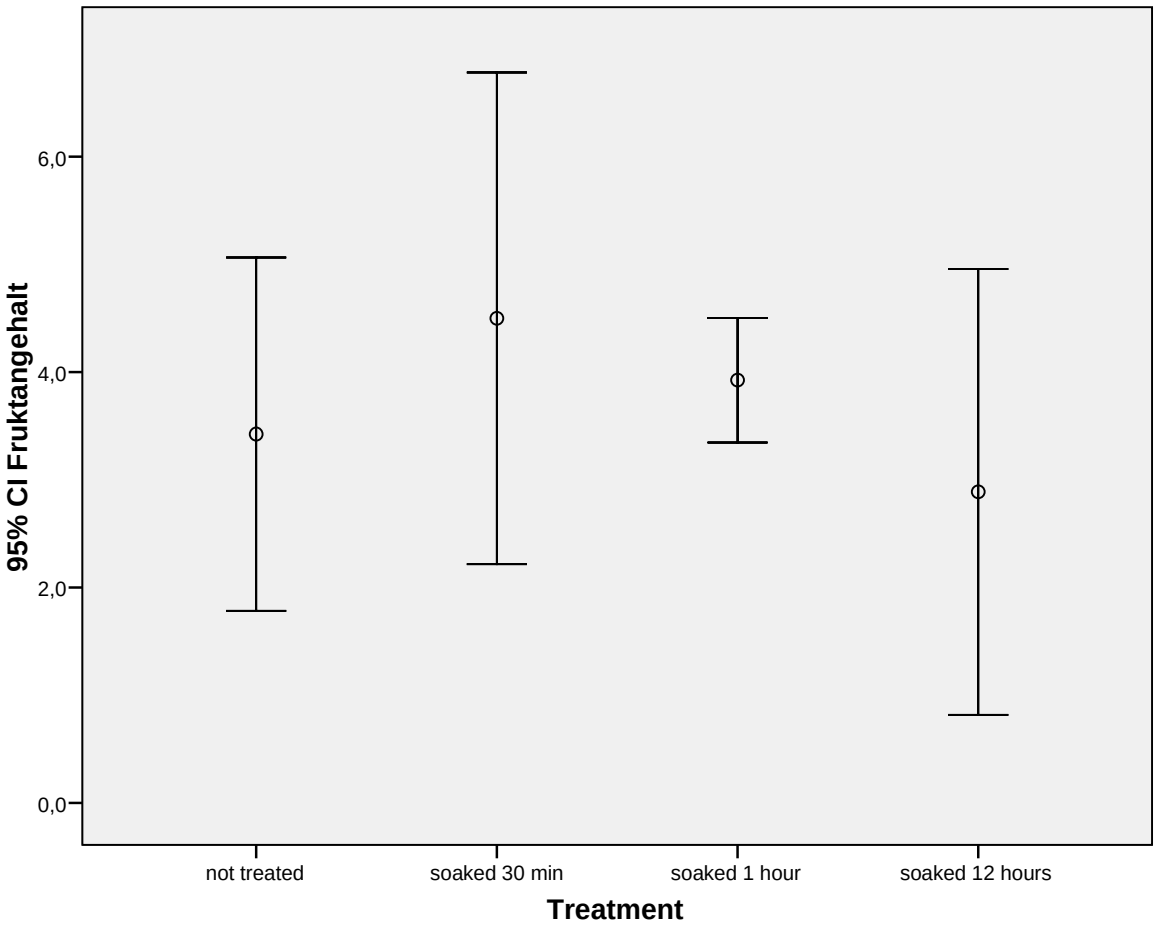
H1: There is a significant difference between the treatment groups and the fructan level

The level of significance $\alpha = 5\%$

ONEWAY ANOVA

Fruktangehalt

	Quadratsumme	df	Mittel der Quadrate	F	Signifikanz
Zwischen den Gruppen	11,403	3	3,801	,848	,479
Innerhalb der Gruppen	125,499	28	4,482		
Gesamt	136,902	31			



Kruskal-Wallis-Test

Ränge

	Treatment	N	Mittlerer Rang
Fructan in groups	not treated	8	15,50
	soaked 30 min	8	20,81
	soaked 1 hour	8	16,38
	soaked 12 hours	8	13,31
	Gesamt	32	

Statistik für Test(a,b)

	Fructan in groups
Chi-Quadrat	2,976
df	3
Asymptotische Signifikanz	,395

a Kruskal-Wallis-Test
b Gruppenvariable: Treatment